Evaluation of Rainfall Bias-Corrected in High Resolution CORDEX-SEA over Java Island

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"Session A3: Statistical Methods/Machine Learning techniques for regional climate modelling/downscaling"

Abstract

This study assesses the performance of rainfall bias-corrected in high-resolution (5 km) simulation from Coordinated Regional Climate Downscaling Experiment-Southeast Asia (CORDEX-SEA) across Java Island, Indonesia. Historical data from three different forcing Global Climate Model (GCMs), including EC-Earth, HadGEM, and MPI, is corrected using observation data from CHIRPS with Quantile Delta Mapping (QDM) technique. Rainfall bias-corrected shows an increase in accuracy in which correlations well improve especially in highland area and bias value significantly decreases from above 60% to near zero. In general, bias-corrected Regional Climate Model (RCM)-5km of EC-Earth has the best improvement compared to other forcing GCMs. Future rainfall data of bias-corrected RCM-5km is expected to have a less steep decreasing annual rainfall trend than the uncorrected one. Decreasing rainfall of bias-corrected RCM-5km is about 4.17 mm/year for RCP 4.5 and 4.35 mm/year for RCP 8.5. A future decreasing seasonal precipitation trend is much steeper in SON, followed by DJF and JJA. MAM has almost no trend of precipitation changes. In the early century, some parts of Java will experience wetter conditions, particularly in DJF, MAM, JJA over mountain regions. At the mid and end of century, Java will experience drier conditions at the western and southern part of Java especially in RCP 8.5.

Background

In recent decades, higher-resolution regional climate models (RCMs) have been frequently utilized to downscale general circulation model (GCM) simulations and offer fine-scale regional climate information.However, systematic biases in climate model simulations compared to observations are common for a variety of reasons. These biases are needed to be corrected before being used for application. There are various bias correction methods used to correct model data ranging from basic scaling method to complex distribution mapping. Quantile delta mapping (QDM) is one of the most used methods for reducing bias in rainfall dataset between output model and observation data (Fauzi et al 2020; Tong et al 2021. As QDM showed good performance in previous studies, this present study aims to evaluate the performance of rainfall bias-corrected using QDM in high resolution (5km) CORDEX-SEA across Java Island, Indonesia for **history (1981-2005)** and **projections (2006 - 2099)** datasets under two scenarios RCP4.5 and RCP8.5.

Data and Methods

Data

- Hydrostatic 25km RegCM dynamically Downscaled 3 GCMs (**RCM-25km**) : MPI, HadGEM2, EC-EARTH
- RCM-25km is further downscaled to the 5km resolution (RegCM4.7.1) (**RCM-5km)**
- **CHIRPS** precipitation dataset with resolution of 0.05º (~5 km) with period of 1981-2005)

RegCM Setup

- Boundary layer scheme: Holtslag PBL; Radiation: CCSM; Land surface treatment: CLM45; Large scale moisture: Subex, 2000; Cumulus convection parameterization: MIT-Emanuel (1991); Ocean flux treatment: Zeng et al (1998).

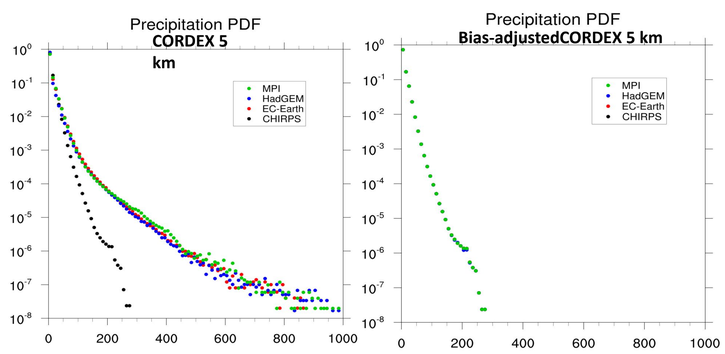
Bias Correction

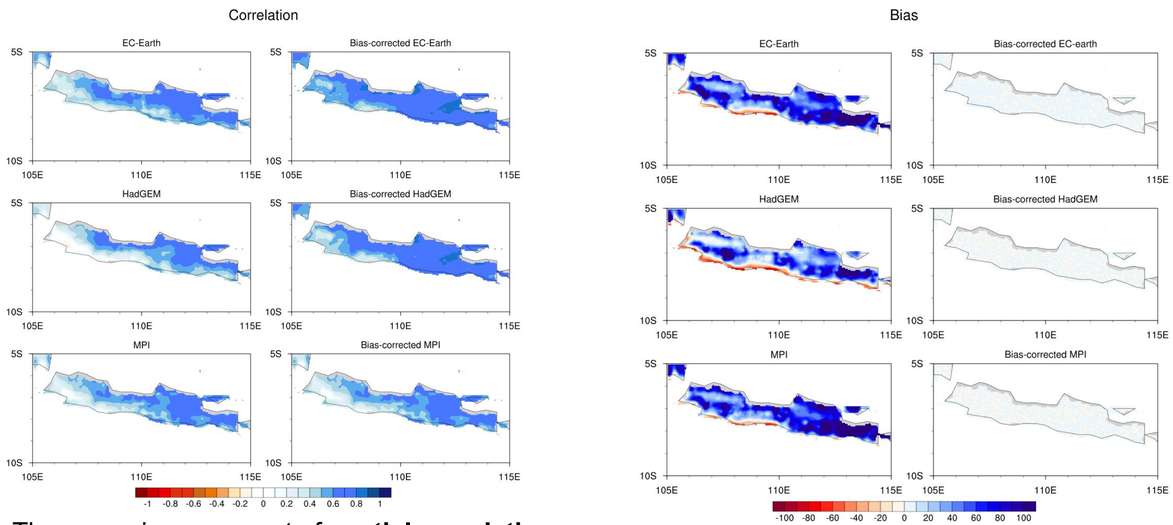
- Bias correction using R package **downscaleR** (Bedia et al., 2020; 2021) (https://rdrr.io/github/SantanderMetGroup/downscaleR/man/biasCorrection.html)
- **Quantile Delta Mapping (QDM)** explicitly preserves the change signal in all quantiles (Cannon et al. 2015). It consists on
  1. detrending the individual quantiles;
  2. QM is applied to the detrended series;
  3. the projected trends are then reapplied to the bias-adjusted quantiles.
- **Daily precipitation** of CORDEX 5 km historical datasets was bias-adjusted according to CHIRPS 5km over Java Island and then the bias correction were applied to CORDEX 5km projections datasets (RCP4.5 and RCP8.5).

Results

Rainfall data in high resolution CORDEX over Java Island shows high overestimation for extreme rainfall compared to observation.

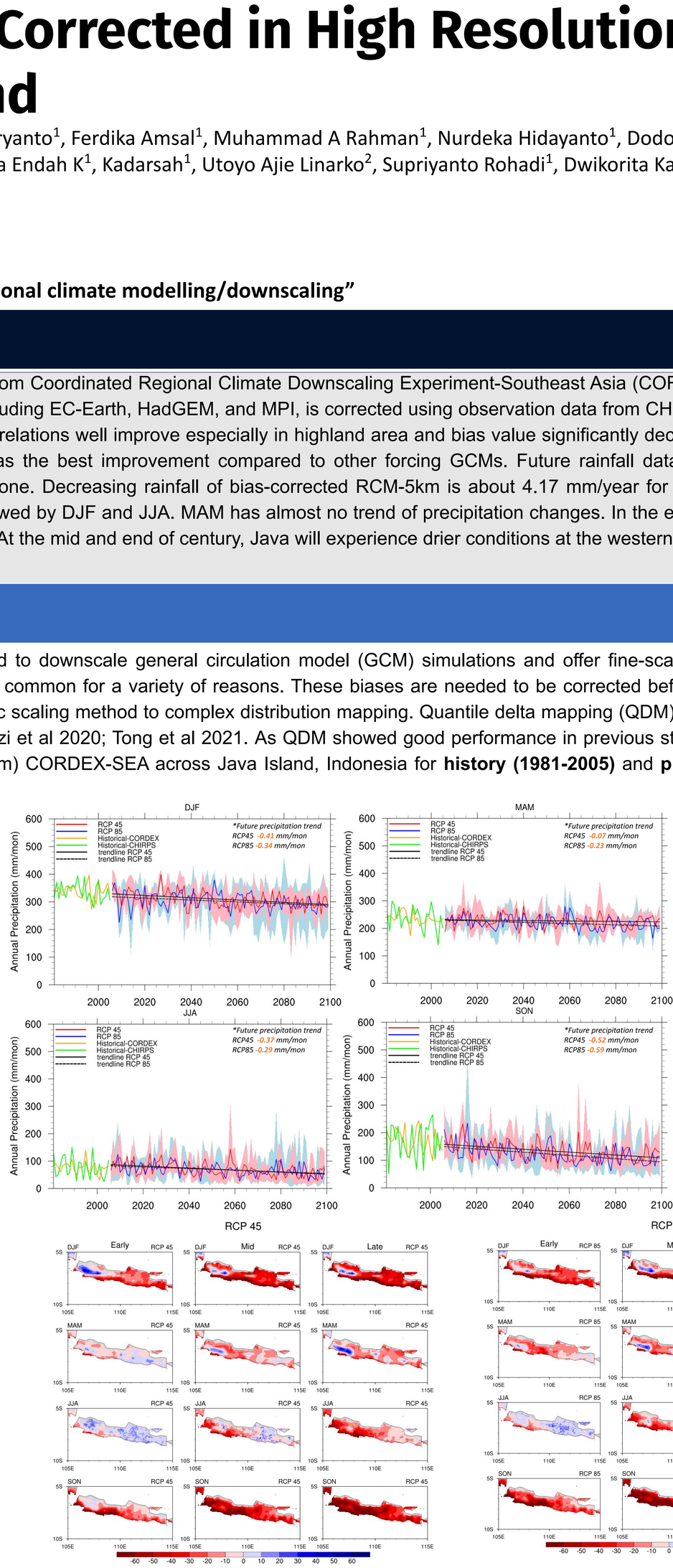
The QDM approach was able to significantly eliminate the biases that were present in the RCMs for daily rainfall.





There was improvement of **spatial correlations** between bias-corrected CORDEX 5km and observation especially over East Java

There were **significant biases improvement** between CORDEX 5km and bias-corrected CORDEX 5km



Bias-Corrected RCM-5km expected a less steep decreasing precipitation trend than un-corrected RCM-5 km in the future. A similar trend between RCP4.5 and RCP8.5

A future decreasing seasonal precipitation trend is much steeper in SON

At early 21st century, some part area of Java Island will experience wetter condition, but at the end century most of area will experience drier conditions especially during SON.

Conclusions

Bias-corrected RCM-5km provides added-values by reducing the rainfall overestimation and improving spatial correlations from 0.2 - 0.7 to 0.2 to 0.9. Bias-corrected RCM-5km of EC-Earth has the best improvement compared to other forcing GCMs. Bias-corrected RCM-5km expected a less steep decreasing annual precipitation trend than uncorrected RCM-5km in the future. A future decreasing seasonal precipitation trend is much steeper in SON, followed by DJF and JJA. MAM has almost no trend of precipitation changes. (supporting previous studies). At the early century, some parts of Java will experience wetter conditions, particularly in DJF, MAM, JJA over mountain regions. At the mid and end of century, Java will experience drier conditions with much drier conditions at the western and southern part of Java.

References

1. Fauzi F, Kuswanto H, Atok RM. 2020. Bias correction and statistical downscaling of earth system models using quantile delta mapping (QDM) and bias correction constructed analogues with quantile mapping reordering (BCCAQ). Journal of Physics: Conference Series
2. Tong Y, Gao X, Han Z. *et al.* 2021. Bias correction of temperature and precipitation over China for RCM simulations using the QM and QDM methods. *Clim Dyn.* 57: 1425–1443
3. Bedia et al. (2020) Statistical downscaling with the downscaleR package (v3.1.0): contribution to the VALUE intercomparison experiment. **Geosientific Model Development**, 13, 1711–1735, https://doi.org/10.5194/gmd-13-1711-2020

Presented in International Conference on Regional Climate ICRC-CORDEX 2023 (Trieste, Italy, 25-29 September 2023)